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Performance Evaluation and Selection of Improved Food Barley (*Hordeum vulgare* L.) Varieties for their Adaptability in West Hararghe Zone, Eastern Oromia, Ethiopia

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Abstract

An experiment was conducted in three districts of West Hararghe Zone at Gemechis (Quni segeria FTC), Chiro (Arbarakate FTC) and Tullo (Gara qufa FTC) in 2018 cropping season in order to identify and promote well performed and adapted improved barley variety/s. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Ten (10) improved barley varieties including local check were used as experimental materials. The most important data of the trial like days to50% flowering, Days to maturity, plant height, spike length, diseases, Plant aspect and yield qt ha^{-1} were collected and analyzed using Genstat 16th edition statistical software and means were separated using least significance difference. Almost most parameters (Days to heading, days to maturity, spike length and grain yield) analysed from individual location were significantly affected due to the main effect of both locations and Environments. Combined analysis of data revealed that, varieties varied significantly at (P<0.05) for all traits. From the overall analysed data, HB1307 and Bentu were the two varieties showed relatively better yield with a value of 46.55and 44.07 qtha^{-1} respectively. HB1965, Shage and Abdane were the least performing varieties interms of grain yield having a value of 37.43, 36.83 and 38.63 qt ha^{-1} respectively. Generally, HB1307 and Bentu were the two varieties showed better performance with their mean yield and other measured traits. Therefore, these two varieties were recommended to be demonstrated under farmers' field for further scaling up.

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Adaptation, Barley Variety, Grain yield, Selection

Introduction

Barley (*Hordeum vulgare* L.) is a major cereal crop in Ethiopia and accounts for 20% of the total cereal production (Wosene *et al.,* 2015). It is grown in a wide range of agro climatic regions under several production systems. Barley grows best on well drained soils and can tolerate higher levels of soil salinity than most other crops. Food barley is commonly cultivated in stressed areas where soil erosion, occasional drought or frost limits the ability to grow other crops (Berhanu *et al.,* 2005). Barley has persisted as a major cereal crop through many centuries and it is the world's fourth important cereal crop after wheat, maize and rice (Martin *et al.,* 2006). The area devoted to barley production in Ethiopia over the past 25 years has fluctuated. It was around 0.8 million hectares in the late 1970s, and rose to more than 1 million hectare in the late 1980s.

It then declined and remained between 0.8 and 0.9 million hectare until the beginning of the third millennium. The production of barley, by-and-large, has been below 1 million tons per year for most of the past 25 years, except during the years when the area under barley increased above 1 million hectare. Productivity, however, has never increased above 1.3 tone ha^{-1}, which is about half the world average Barley has a long history of cultivation in Ethiopia as one of the major cereal crops and it is reported to have coincided with the beginning of plow culture (Mulatu and Grando, 2011).

It is the most important crop with total area coverage of 951,993.15hectares and total annual production of about 21.57 qtha^{-1}in Ethiopia, 451,279.26 hectares with24.12qtha^{-1} in Oromia,and 6,737.49ha in West Hararghe Respectively(CSA, 2018). In the highlands of the country barley is grown in Oromia, Amhara, Tigray and part of the Southern Nations, Nationalities and Peoples' Regional State (SNNPR) in the altitude ranges of 1500 and 3500m, but it is predominantly cultivated between 2000 and 3000 masl (MoA, 1998). In Ethiopia, barely is a dependable source of food in the highlands as it is produced during the main and short rainy seasons as well as under residual moisture (Melle *et al.*, 2015). Barley types are predominantly categorized as food and malting barley based on their uses, while in Ethiopia the highest proportion of barley production area is allocated for food barley. Food barley is principally cultivated in the highland areas of Ethiopia where the highest consumption is in the form of various traditional foods and local beverages from different barley types (Zemede, 2000). Barley grain accounts for over 60% of food for the highlands of Ethiopia, for which it is the main source of calories (Ceccarelli *et al.*, 1999). According to (Berhanu *et al.*, 2005), barley is used in diversity of recipes and deep rooted in the culture of people's diets. Besides its grain value, barley straw is an indispensable component of animal feed especially during the dry season in the highlands where feed shortage is prevalent (Girma *et al.*, 1996). Barley straw is also used in the construction of traditional huts and grain stores as thatching or as a mud plaster, as well as for use as bedding in the rural areas (Zemede, 2000).

Barley is an important crop in Ethiopian cereal production and in food security (Berhanu *et al.*, 2005). It is currently the fifth most important cereal crop, covering over one million hectares of land. It is grown both in Meher (June–October) and Belg (February–May) seasons. Meher production in the country is categorized into early, intermediate and late production systems. The contribution of the early production system is estimated to be 25% of total barley production. Although barley is considered a highland crop, it is also among the major cereal crops grown in the low rainfall areas of the country, which are part of the early production system. In such areas, the availability and distribution of rainfall during crop growing seasons is the major factor limiting yield. Early ear emergence is the most important feature of barley adaptation to the low moisture areas and is common in Ethiopian landraces from these areas. Thus, the farmers in drought-prone areas grow their own landraces that are well adapted to their environments, but with poor yielding ability. Hence, it was considered essential that barley productivity in low moisture areas be improved to increase the contribution of this system to overall barley grain production.

Although Ethiopia is a center of diversity for barley, most of the farmers in the country still obtain very low yields due to a combination of genetic, environmental and socioeconomic constraints. Research has been on-going since 1955 to address these constraints and improve the livelihoods of farmers by increasing the production and productivity of barley (Mulatu and Grando, 2011).

West Hararghe Zone is among some of the places in the region where food barley is grown as one of the major cereal food crops of highland and midland agro ecology. Most farmers of the zone produce food barley on hectares of land (CSA, 2016). However, their average productivity is low per hectare because the existing cultivation is not supported with new and better technologies such as high yielding and adaptive varieties with improved cultivation practices. A critical shortage of improved barley varieties adapted to low-moisture stress conditions is a major problem and hence farmers are forced to grow low yielding genotypes. Drought is one of the major production constraints that reduce crop yields in water-limited areas, where many of the farmers live. This is a serious problem in places where total precipitation is high but unevenly distributed throughout the growing season. As the population continues to grow and water resources for crop production decline, development of drought-tolerant cultivars and water use-efficient crops is a global concern. In the low-rainfall areas (<250 mm annual precipitation) and in most rain fall limiting areas, barley is the dominant crop. Before the 1980s, drought was most protracted in the northern and eastern regions of Ethiopia. However, the number of drought-affected areas has dramatically increased and now includes the most productive regions in the east. Not only is this, but also due to shortage of land in the study area, double cropping system of barley is commonly practiced in the study area to increase their income generation per unit area. Therefore, this study was initiated with the objective of the following:

Objective: To select the best adaptive food barley varieties with high yield and good agronomic trait to the area.

Materials and Methods

Description of the study area

The experiment was conducted at Tullo (Gara Qufa FTC), Gemechis (Quni segeria FTC) and Chiro (Arbarakate FTC) during 2018 main cropping season. Tullo district is found in West Hararghe Zone of Oromia National Regional State, Eastern part of Ethiopia. The district is located about 375 km southeast of Addis Ababa and 47 km from Chiro town, the capital of West Hararghe Zone (DOA, 2012). Hirna is found within 1758 m above sea level (m.a.s.l). It receives an average annual rainfall of 868mm. The average temperature is 22°C. The black, vertisols and red soils are the three dominant soil types. Gemechis district is found in West Hararghe Zone of Oromia National Regional State, Eastern part of Ethiopia. The district is located about 343 km southeast of Addis Ababa and 17 km from Chiro town, the capital of West Hararghe Zone (DOA, 2012). The district is found within 1300 to 2400 above sea level (m.a.s.l). It receives an average annual rainfall of 850mm. The district has bimodal distribution in nature with small rains starting from March/April to May and the main rainy season extending from June to September/October. The average temperature is 20°C. The black, brown and red soils are the three dominant soil types constitute 55, 25 and 20%, respectively (DOA, 2012). Chiro district is located in West Hararghe Zone of the Oromia National Regional state at about 324 km East of

Addis Ababa, the capital city of Oromia regional national state. The capital town of the district is Chiro, which is also the capital town of the Zone. The district is founded at an average altitude of 1800 m.a.s.l. It has a maximum and minimum temperature of 23^{o}c and 12^{o}c respectively and the maximum and minimum rainfall of 1800 mm and 900 mm respectively (2003 E.C data from Office of Agriculture of the district). The district is mainly dominated with sandy soil, clay soil (black soil) and loamy soil types covering 25.5%, 32%, and 42.5% respectively according to 2003 E.C data from Office of Agriculture and Rural Development. The soil types vary with the topography mainly black soils are observed in the highland and midlands while one can see red soil inthe lowland areas.

Experimental treatments and design

Nine recently released food barley varieties were brought from Sinana Agricultural Research Center and one local check of the respective sub-testing locations were evaluated as experimental materials. These varieties include HB1965, HB1966, Gobe, Robera, Abdane, Bentu,HB-1307, Shage, EH-1493 and Local check. These materials were randomly assigned to the experimental block and the experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The spacing between blocks and plots was 1.5m and 1m, respectively. The gross size of each plot was 3m^2 (1.2m x 2.5m) having six rows with a row-to-row spacing of 20cm.The total area of the experimental field was 270m^2 (41m x 6.6m).Planting was done by drilling seeds in rows with a seed rate of 100kg ha^{-1} (30g per plot). NPS fertilizer was applied at the rate of 100kg ha^{-1} (30g per plot) at the time of planting; and Urea was also applied at vegetative stage before booting at the rate of 50 kg ha^{-1} (15g per plot).

Data collected

Data was collected from five plants of six rows of each plot and randomly tagged and the relevant data was recorded. The followings are the major parameters recorded:

Days to 50% emergence (days) Grain yield (qt ha^{-1})
Days to 50% heading (days) Disease Data (scale)
Days to 75% physiological maturity (days) Plant height (cm) Spike length (cm) Plant aspect

Data analyses

Genstat 16th Edition was used to analyze all the collected data from individual locations and the combined data over locations. Various statistical models such as analysis of variance (ANOVA), principal component analysis (PCA) and the additive main effects and multiplicative interaction (AMMI) model. In this model, the additive and multiplicative components of data were integrated into a powerful least square analysis. GGE biplot was used. Mean separations was carried out using least significant difference (LSD) at 5% probability level.

Results and Discussions

Days to 50% flowering (days): Statistical analysis of variance for days flowering were showed significant difference at P≤0.05 at all testing individual location (Table.1). The performance of varieties for days of flowering in combined analysis among varieties and within location were also showed a significance difference at (P≤0.05) in table 2. Among the tested barley varieties evaluated, Shage (82 days) late flowering and the shortest day was recorded by Abdane (54.67 days). Therefore, Abdane was considered as earliest flowering variety as compared to other varieties tested together.

Maturity date (days): Analysis of variance shows that the individual location data analysis for days of maturity showed significant difference for all varieties at all tested locations (Table 1), but the combined mean effects of varieties showed non-significant difference for all varieties (Table 2). The longest days of maturity in combined mean effect of varieties were recorded by HB1966 variety which is (105.3 days) and shorter by Abdane which is (98.3 days) to attain its full physiological maturity.

Plant height (cm): Analysis of variance shows a significant variation except at Arbarakate FTC observed non-significance difference. The combined mean effect of plant height within variety and location showed a significant difference at P≤0.05 (Table 2). Generally, Shage variety was recorded the highest plant height of (82.14 cm) and Bentu was recorded the lowest (70.04 cm).

Table.1 Mean values of Barley varieties on grain yield and yield components in each districts of West Hararghe Zone in 2018 cropping season

	Gemechis (Quni segeria FTC)					Chiro (Arbarakate FTC)					Hirna (Gara Qufa FTC)				
Varieties	**DF**	**DM**	**PH**	**SL**	**Yld**	**DF**	**DM**	**PH**	**SL**	**Yld**	**DF**	**DM**	**PH**	**SL**	**Yld**
HB1965	81.0^{ab}	114.7^{ab}	76.47^{b-e}	9.47^{ab}	37.85^{b}	54.0^{c}	94.67^{b}	74.73	6.7^{b}	36.02^{b}	65^{bc}	98.0^{c}	71.47^{f}	7.8^{a}	38.41^{a}
HB1966	71.3^{a-d}	118.7^{a}	82.13^{a-d}	8.60^{a-c}	37.74^{b}	69.3^{ab}	96.33^{ab}	71.00	7.8^{ab}	50.96^{a}	70^{a-c}	101^{ab}	80.60^{cd}	7.6^{ab}	33.9^{ab}
Gobe	70.3^{a-d}	100.7^{ab}	71.67^{e}	8.73^{a-c}	46.96^{ab}	54.0^{c}	96.33^{ab}	72.67	7.5^{ab}	42.52^{ab}	73^{ab}	98.7^{c}	72.07^{ef}	7.6^{ab}	41.18^{a}
Robera	64.0^{b-d}	101.0^{ab}	73.80^{c-e}	8.00^{cd}	53.52^{ab}	56.0^{c}	96.00^{ab}	67.20	7.13^{b}	44.40^{ab}	65^{bc}	99^{bc}	71.33^{f}	6.5^{c}	31.0^{a-c}
Abdane	54.0^{d}	98.0^{b}	82.13^{a-d}	8.46^{bc}	54.07^{ab}	55.0^{c}	97.33^{ab}	73.53	8.0^{ab}	37.07^{b}	55.0^{c}	99^{bc}	77.8^{de}	8.1^{a}	24.7^{bc}
Bentu	64.0^{b-d}	98.0^{b}	72.87^{de}	8.13^{cd}	67.19^{a}	54.0^{c}	98.67^{a}	74.60	8.7^{a}	34.52^{b}	65^{bc}	99^{bc}	62.67^{g}	7.0^{bc}	30.5^{a-c}
HB1307	79.7^{ab}	110.0^{ab}	83.00^{a-c}	7.93^{cd}	48.96^{ab}	65.3^{b}	97.67^{ab}	72.93	7.7^{ab}	50.29^{a}	75^{ab}	101^{ab}	84^{a-c}	7.6^{ab}	40.40^{a}
Shage	84.7^{a}	110.7^{ab}	91.13^{a}	9.60^{a}	38.41^{b}	74.6^{a}	96.67^{b}	68.73	7.5^{ab}	40.30^{ab}	86.6^{a}	103^{a}	86.6^{ab}	7.8^{a}	31.7^{a-c}
EH1493	72.7^{a-c}	112.7^{ab}	81.40^{b-d}	9.0^{a-c}	58.85^{ab}	74.6^{a}	96.33^{ab}	67.73	6.9^{b}	31.84^{b}	86^{a}	102^{a}	81^{b-d}	8.2^{a}	39.11^{a}
Local check	58.0^{cd}	108.7^{ab}	83.80^{ab}	7.20^{d}	45.52^{ab}	57.6^{c}	95.33^{ab}	68.80	7.9^{ab}	43.96^{ab}	55^{c}	98^{c}	88.0^{a}	6.6^{c}	28.7^{cd}
GM	69.97	107.30	79.84	8.51	48.91	61.5	96.53	71.2	7.59	41.19	69.7	100.	77.6	7.5	33.98
CV%	14.9	10.9	6.8	7.7	26.1	5.4	2.3	13.4	11.3	18.0	13.7	1.2	4.4	6.1	17.8
LSD(0.05)	17.9	19.9	9.29	1.13	21.87	5.7	3.86	NS	1.46	12.74	16.3	2.04	5.89	0.79	10.35

DF= Days to flowering (days), DM= days to maturity (days), PH= plant height (cm), SL= spike length (cm), Yld= Grain yield (qt ha^{-1}), GM= Grand mean, CV= Coefficient of variation, LSD= Least significance difference

Table.2 Combined Mean effect of locations by varieties on yield related components at Quni, Arbarakate and Gara Qufa FTC in 2018 cropping season

Varieties	**DF**	**DM**	**PH**	**SL**	**Dis**	**PAS**
HB1965	66.67^{c-e}	102.4	74.22^{b-d}	8.00^{ab}	1.44^{c}	1.55
HB1966	70.44^{b-d}	105.3	77.91^{a-c}	8.00^{ab}	1.88^{a-c}	1.77
Gobe	65.89^{c-e}	98.6	72.13^{cd}	7.97^{ab}	1.88^{a-c}	1.77
Robera	61.67^{d-f}	98.7	70.78^{cd}	7.22^{b}	1.88^{a-c}	1.44
Abdane	54.67^{f}	98.3	77.82^{a-c}	8.22^{a}	1.88^{a-c}	1.44
Bentu	61.00^{d-f}	98.8	70.04^{d}	7.95^{ab}	2.55^{a}	2.33
HB1307	73.44^{a-c}	102.9	80.03^{ab}	7.75^{ab}	1.77^{bc}	1.33
Shage	82.00^{a}	103.4	82.14^{a}	8.31^{a}	1.44^{c}	4.66
EH1493	77.78^{ab}	103.8	76.82^{a-d}	8.04^{ab}	1.33^{c}	1.77
Local check	56.89^{ef}	100.7	80.20^{ab}	7.24^{b}	2.33^{ab}	1.88
GM	67.04	101.29	76.21	7.87	1.84	1.99
CV%	15.6	8.5	10.7	12.2	40.4	
LSD(0.05)	9.83	NS	7.62	0.89	0.69	

DF= Days to flowering (days), DM= days to maturity (days), PH= plant height (cm), SL= spike length (cm), Dis=diseases score (1-5scale), PAS=plant aspect, GM= Grand mean, CV= coefficient of variation, LSD= Least significant difference

Table.3 Mean grain yield (qt ha^{-1}) of 10 barley varieties at individual environment

Varieties	Quni FTC	Arbarakate FTC	Gara qufa FTC	Combined Mean	Yld Advantage (%)
HB1965	37.85^{b}	36.02^{b}	38.41^{a}	37.43	-
HB1966	37.74^{b}	50.96^{a}	33.95^{ab}	40.88	-
Gobe	46.96^{ab}	42.52^{ab}	41.18^{a}	43.55	10.53
Robera	53.52^{ab}	44.40^{ab}	31.01^{a-c}	42.98	-
Abdane	54.07^{ab}	37.07^{b}	24.74^{bc}	38.63	-
Bentu	**67.19^{a}**	**34.52^{b}**	**30.51^{a-c}**	**44.07**	**11.85**
HB1307	**48.96^{ab}**	**50.29^{a}**	**40.40^{a}**	**46.55**	**18.15**
Shage	38.41^{b}	40.30^{ab}	31.79^{a-c}	36.83	-
EH1493	58.85^{ab}	31.84^{b}	39.11^{a}	43.27	-
Local check	45.52^{ab}	43.96^{ab}	28.74^{bc}	39.40	-
GM	48.91	41.19	33.98	41.36	
CV%	26.1	18.0	17.8		
LSD(0.05)	21.87	12.74	10.35		

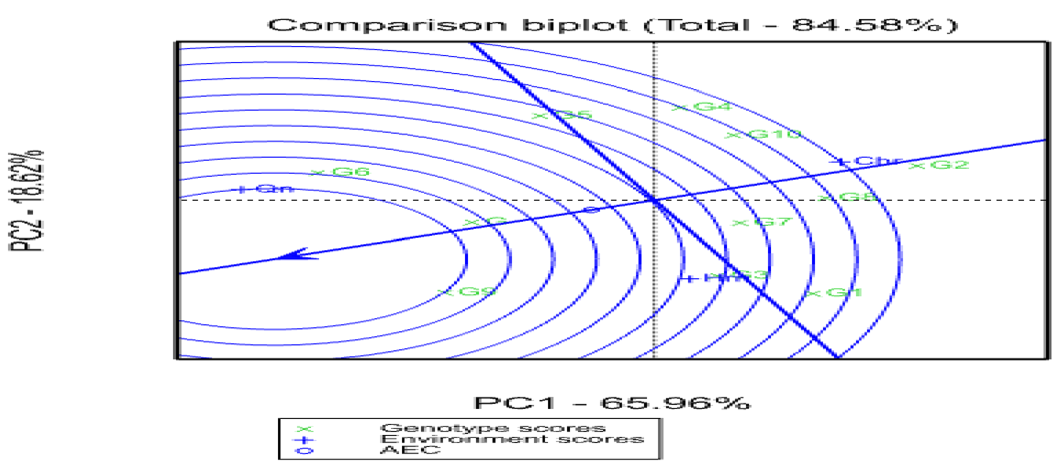
Yld= Grain yield,GM= Grand mean, CV= coefficient of variation, LSD= Least significant difference

Table.4 AMMI analysis of variance for grain yield (qt ha^{-1}) of 10 barley varieties tested at three locations during 2018 main cropping season

Source	DF	SS	MS	SS%	F cal.	F pr
Total	89	13289	149.3			
Treatments	29	7857	270.9**	59.12	3.20	<0.001
Genotypes	9	836	92.8	6.3	1.10	0.3812
Environments	2	3342	1671.0**	25.15	11.68	<0.001
Blocks	6	858	143.0		1.69	0.1416
Interactions	18	3680	204.4*	27.69	2.41	0.0066
IPCA 1	10	2887	288.7	78.45	3.41	0.0016
IPCA 2	8	792	99.0	21.52	1.17	0.3345
Residuals	0	0				
Error	54	4573	84.7			

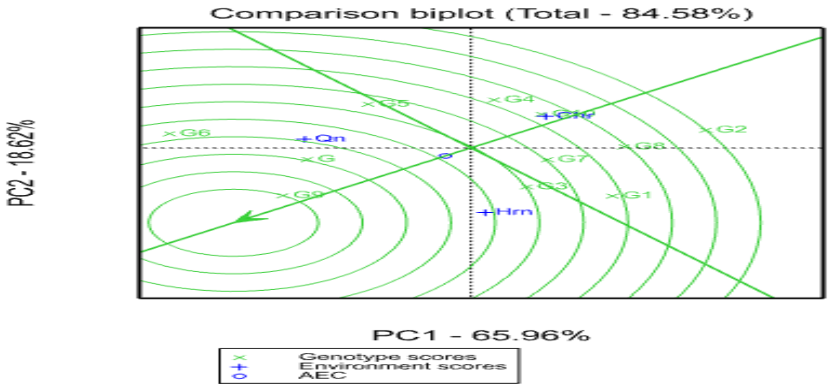
DF=Degree of freedom, SS= Sum of squares, MS= Mean of squares, SS%= percentage of sum of squares, *= significant, **= highly significant

Fig.1 GGE biplot analysis showing the stability of genotypes and test environments



Key: G1= HB1965, G2= HB1966, G3=Gobe, G4= Robera, G5= Abdane, G6= Bentu, G7= HB1307, G8= Shage, G9= EH1493, G10= Local

Fig.2 The average genotypes coordination (AGC) views to rank genotypes relative to the center of concentric circles



Key: G1= HB1965, G2= HB1966, G3=Gobe, G4= Robera, G5= Abdane, G6= Bentu, G7= HB1307, G8= Shage, G9= EH1493, G10= Local check

Fig.3 The GGE biplot to show which genotypes performed best in which environment

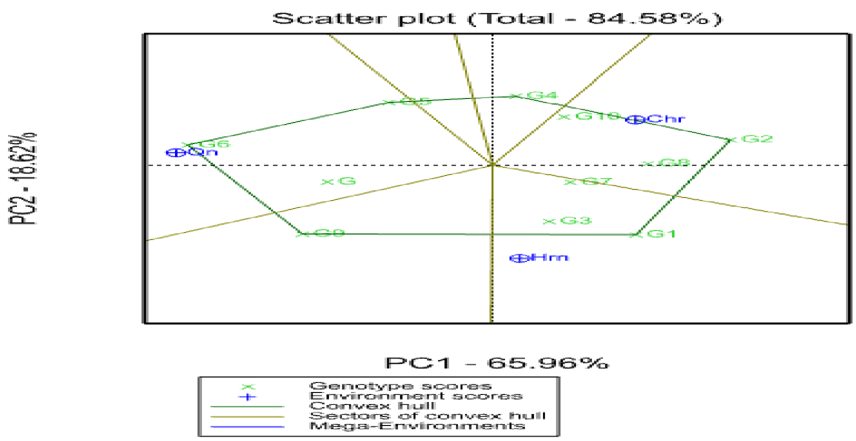


Fig.4

Spike length (cm): Barley varieties were showed a significance difference for spike length at each location as well as combined mean effect of varieties for this trait. A combined analysis of variance showed the highest spike length of (8.31cm) for Shage and the lowest spike length of (7.22cm) for Robera (Table 2).

Grain yield (qt ha^{-1}): Both the individual and combined analysis of the data showed a significant difference at P≤0.05.From the individual location analysis, the highest yield was recorded by Bentu (61.19 qt ha^{-1}) and the lowest for HB1966 (37.74 qt ha^{-1}) at Quni segeria, The highest for HB1966 (50.96 qt ha^{-1}) and the lowest for Bentu (34.52 qt ha^{-1}) at Arbarakate and The highest for Gobe (41.18 qt ha^{-1}) and the lowest for Abdane (24.74 qt ha^{-1}) was recorded. Combined analysis variance for treatment means effect of location interaction was showed significance difference on grain yield qt ha^{-1}(Table 2). The highest yield (46.55 qt ha^{-1}) was recorded for variety HB1307 followed by Bentu (44.07 qt ha^{-1}) and EH1493 (43.27qt ha^{-1}) while the lowest for HB1965 (37.34 qt ha^{-1}).

The ANOVA indicated very highly significant differences (P<0.001) for treatments and environments. The total variation explained (%) was 59.12% for treatment and the remaining % for error. The greater contribution of the treatment than the error indicates the reliability of this multi-location experiment. The treatment variation was largely due to GEI variation (27.69%), genotype that accounted 6.3% and 25.15% for the environment variation, respectively. As discussed earlier, the high percentage of GEI is an indication that the major factor that influence yield performance of barley is the interaction effect of GE. In the AMMI ANOVA the GEI was further partitioned by PCA. The number of PCA axis to be retained is determined by testing the mean square of each axis with the estimate of residual through the F-statistics. The result of ANOVA showed that the first IPCA is very highly significant at P<0.001 probability level and this result suggests the inclusion of the first interactions PCA in the model (Table 4). In particular, the first IPCA captured 78.45% of the total interaction sum of squares while the second IPCA explained 21.52% of the interaction sum of squares.

Genotype Performance per Environment (GGE biplot Analysis)

Test locations which are closer to concentric circles like Quni is important under circumstances when selecting genotypes that are widely adapted which is an ideal environment. An ideal environment is the one which is on the intrinsic circle (Figure 1). Thus, Quni is found on the closer proximity or on the edge of the intrinsic circle followed by Hirna. However, Chiro cannot be ideal test location for selecting cultivars which can be adaptable for the whole region, but can be selected as specific adapted location (Figure 1).

Genotypic stability is quite crucial in addition to genotype yield mean; G9, G3 and G7 were more stable as well as having appropriate yield. The ideal genotype might have the highest mean performance and be absolutely stable which is represented by the dot with an arrow pointing to it (Fig. 2). Such an ideal genotype is defined by having the greatest vector length of the high yielding genotypes. Concentric circles were drawn to visualize the distance between each genotypes and the ideal genotypes; which is more desirable if it is located closer to the ideal genotype, so that G9, G3 and G7 falls near to the center of the concentric circles, which were ideal in terms of their stability(Figure 2).

The polygon view of the GGE-biplot analysis helps one to detect cross-over and non-crossover genotype-by-environment interaction and possible mega environments in multi-location yield trials (Yan *et al.*, 2007). HB1965 (G1), HB1966 (G2), Abdane (G5), Bentu (G6), EH1493 (G9), and Local (G10), were vertex genotypes (Figure 3). They are best in the environment lying within their respective sector in the polygon view of the GGE-biplot and thus these genotypes are considered specifically adapted. Accordingly, G2 was specifically adapted to Chiro, G1 and G3 were adapted to Hirna and G6 was adapted to Quni segeria (Gemechis district).

One of the most attractive features of a GGE biplot is its ability to show the mega environment pattern of a genotype by environment data set (Yan and Tinker, 2006). Many researchers find the use of a biplot analysis, as it graphically addresses important concepts such as cross-over GE, mega environment differentiation, specific adaptation, etc as discussed in Yan and Tinker (2006). The polygon is formed by connecting the markers of the genotypes that are far away from the biplot origin such that all other genotypes are contained in the polygon. Genotypes located on the vertices of the polygon performed either the best or the poorest in one or more locations since they had the longest distance from the origin of biplot. The perpendicular lines are equality lines between adjacent genotypes on the polygon, which facilitate visual comparison of them.

Those genotypes found in the polygon are widely adapted genotypes. For example, G4, G7 and G8 were widely adapted genotypes (figure 3).

In conclusion and recommendation, the studying varietal response to different environment is crucial for plant breeding programmes where there is a diverse natural, environmental, climatic and soil variability is existing. In line with this, a total of 10 barley varieties were studied at three locations (Gemechis (Quni segeria FTC), Chiro (Arbarakate FTC) and Hirna (Gara Qufa FTC) during 2018 main cropping season with the objective to select the best adaptive food barley varieties with high yield and good agronomic trait to the area.

The result of the experiment showed that barley varieties were showed a significant difference both at individual location and combined mean effects. Varieties were highly affected by environments and their interaction which show the selective adaptation to specific location and wider adaptability that favoring their production. Generally, HB1307 and Bentu were the best varieties thatshowed the stability of these varieties as well as higher yield advantage over the local check. Therefore; these two varieties are recommended as improved varieties and demonstrated on farmers' field for further scaling up.

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